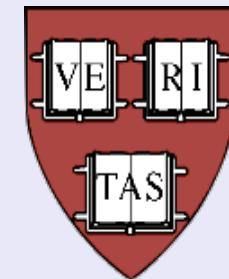


W AND Z BOSON PRODUCTION CROSS SECTION MEASUREMENTS IN ATLAS



Verena I. Martinez Outschoorn
Harvard University

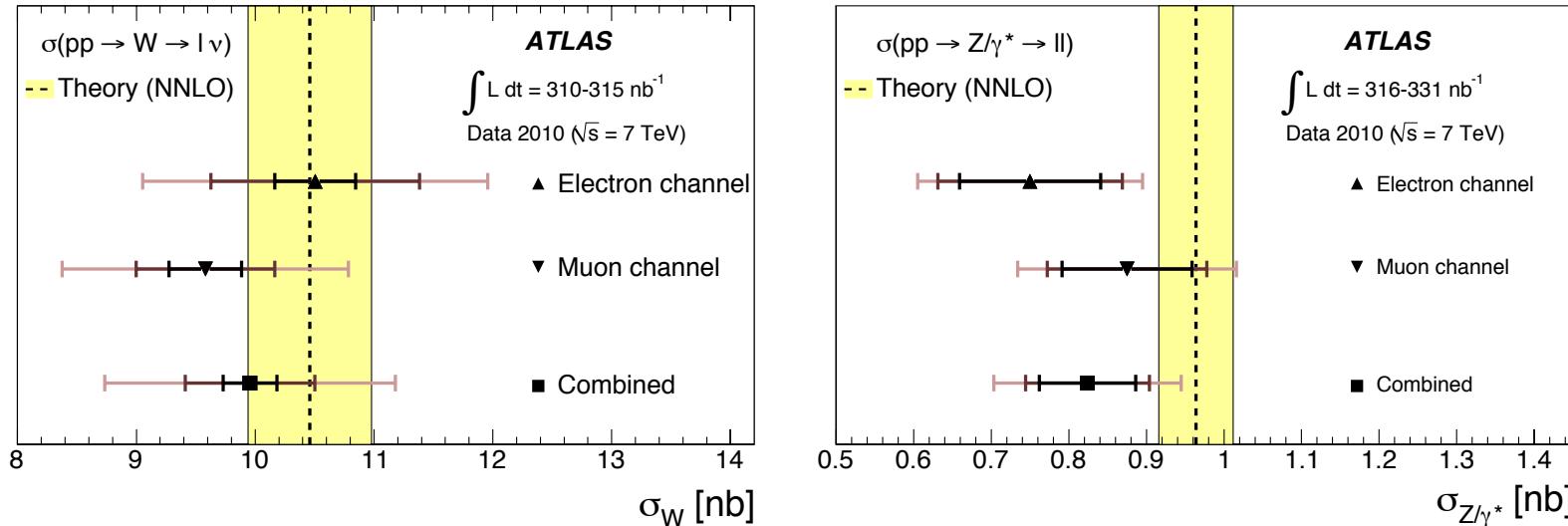
on behalf of the ATLAS Collaboration



DIS 2011, Newport News, VA 11-15 April

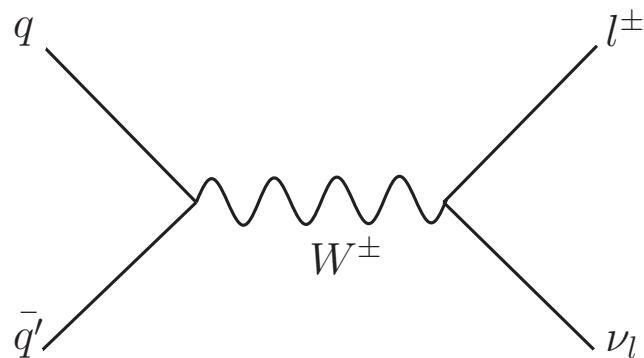
INTRODUCTION AND OVERVIEW

- $W \rightarrow l\nu$ and $Z \rightarrow ll$ ($l = e, \mu$) Cross Section Measurements
 - First measurement $\sim 320 \text{ nb}^{-1}$ establish signatures **JHEP 1012:060, arXiv:1010.2130**

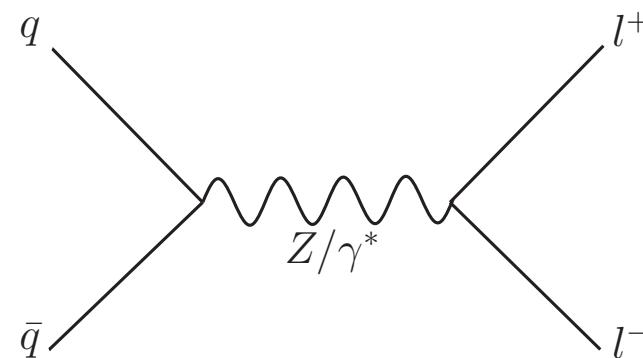


- Update full 2010 dataset 35 pb^{-1} with **reduced statistical and systematic uncertainties**
- **Comparison** with theoretical calculations at **NNLO** level
- $W \rightarrow \tau\nu$ and $Z \rightarrow \tau\tau$ Observation
 - Background to new physics searches such as $H \rightarrow \tau\tau$
 - Performance of τ lepton reconstruction and identification

W \rightarrow lv signature 1 high p_T lepton and E_T^{miss}



Z \rightarrow ll signature 2 opposite-sign high p_T leptons



Cross Section

$$\sigma = \frac{N_{\text{cand}} - N_{\text{background}}}{A_{W/Z} \times C_{W/Z} \times \int \mathcal{L} dt}$$

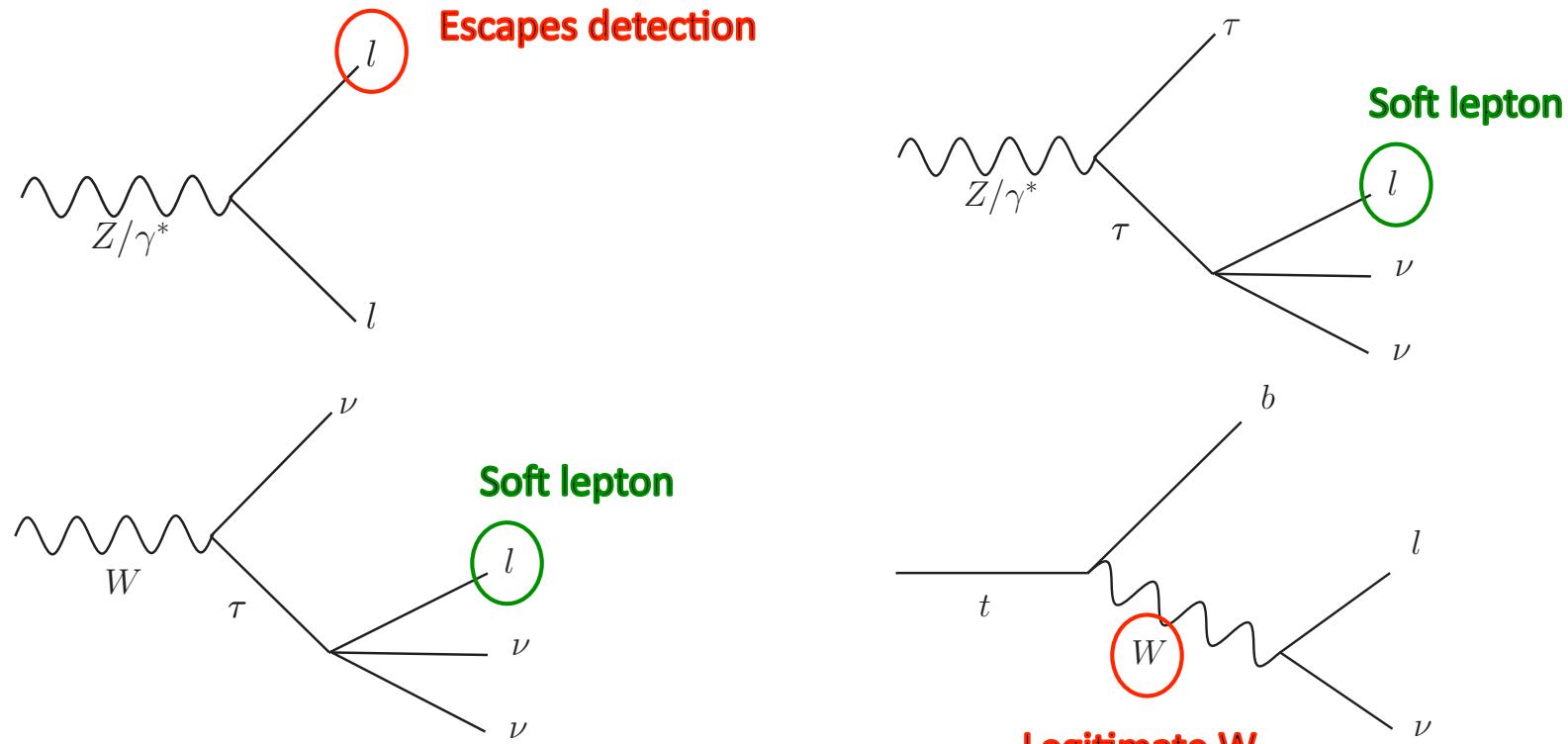
• $\int \mathcal{L} dt$ = integrated luminosity

- N_{cand} = number of selected candidates
- N_{background} = expected number of background events
- A_{W/Z} × C_{W/Z} = fraction of signal expected to pass selection
 - C_{W/Z} = correction for efficiencies and geometric acceptance to fiducial region
 - A_{W/Z} = acceptance factor extending beyond kinematic selection

W AND Z BACKGROUNDS

ATLAS-CONF-2011-041

- EW and top backgrounds estimated from MC



- QCD background
 - Heavy quark decays, hadronic fakes, conversions (electrons)
 - Measured from data
 - Template fits or extrapolations from control regions

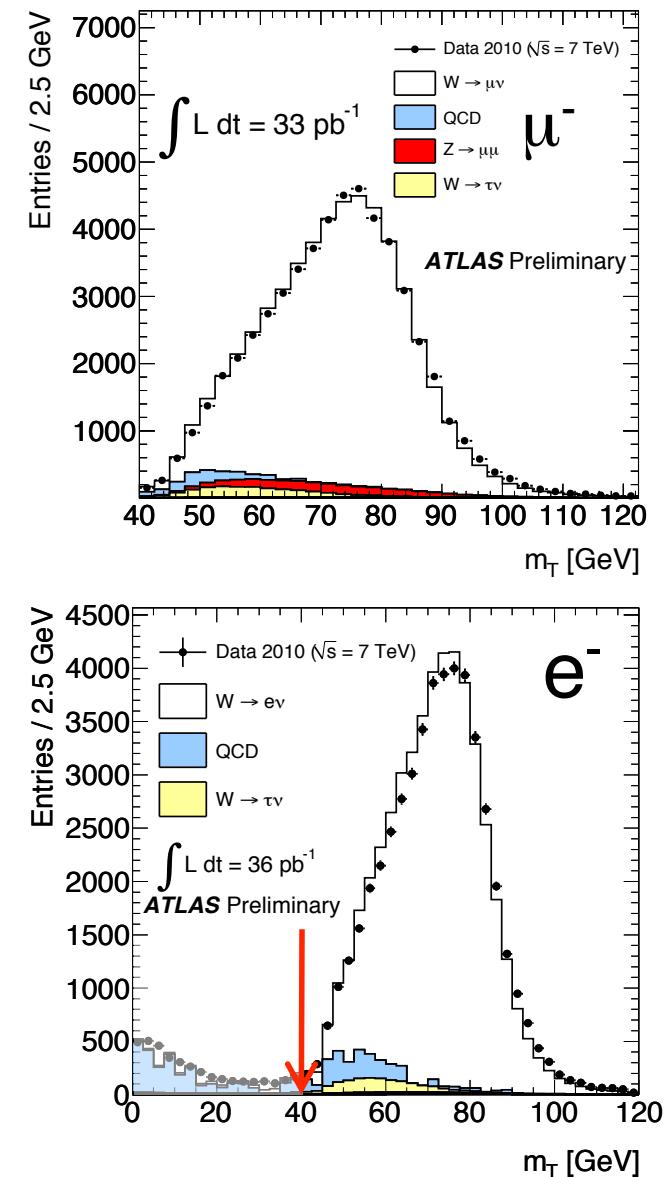
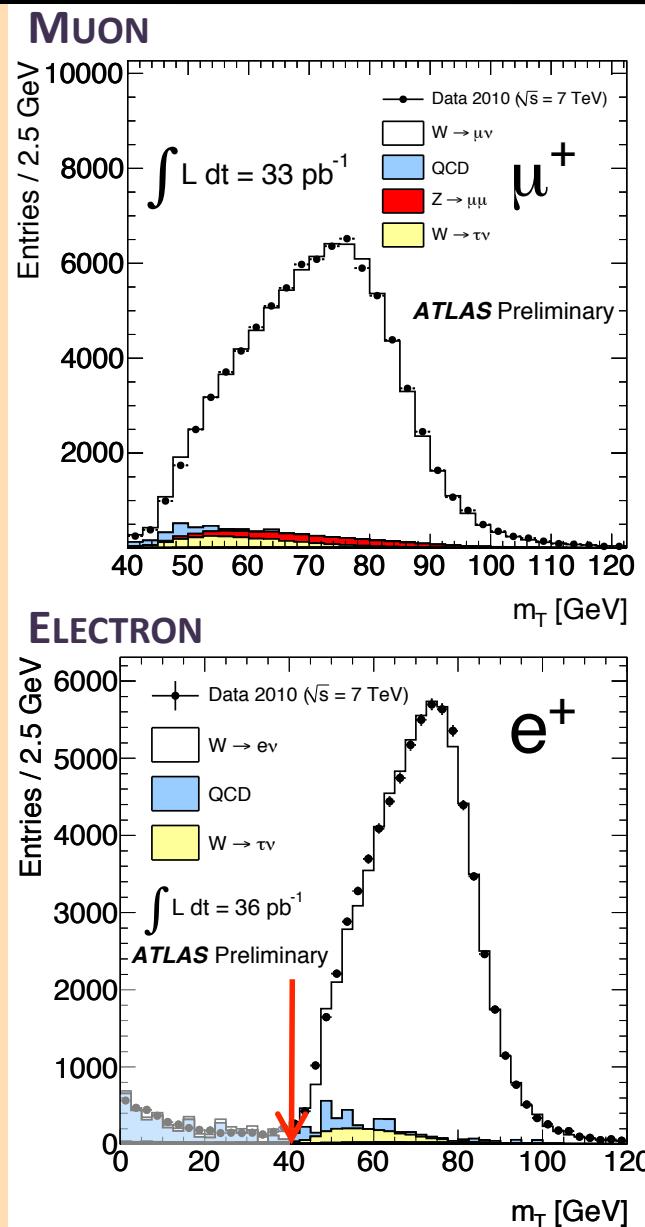
OBJECT DEFINITION

- MUON
 - $p_T > 20 \text{ GeV}$
 - $|\eta| < 2.4$
 - **Combined muons:** Track in Inner Detector and Muon System
 - Vertex cuts
 - Relative track **isolation**
- ELECTRON
 - $E_T > 20 \text{ GeV}$
 - **Central:** $|\eta| < 2.47$
 - **Excluding** calorimeter transition region $1.37 < |\eta| < 1.52$
 - **Forward:** $2.5 < |\eta| < 4.9$
 - **Identification cuts**
 - Shower shapes (central, forward)
 - Track quality and cluster-track matching, E/p (central)
 - Transition Radiation ($|\eta| < 2$)
- MISSING TRANSVERSE ENERGY
$$\vec{E}_T^{miss} = - \sum_{\text{clusters } i} E_i \hat{n}_i - \vec{p}_T^\mu + E_{loss}^\mu \hat{p}_T^\mu$$

W BOSON CANDIDATES

ATLAS-CONF-2011-041

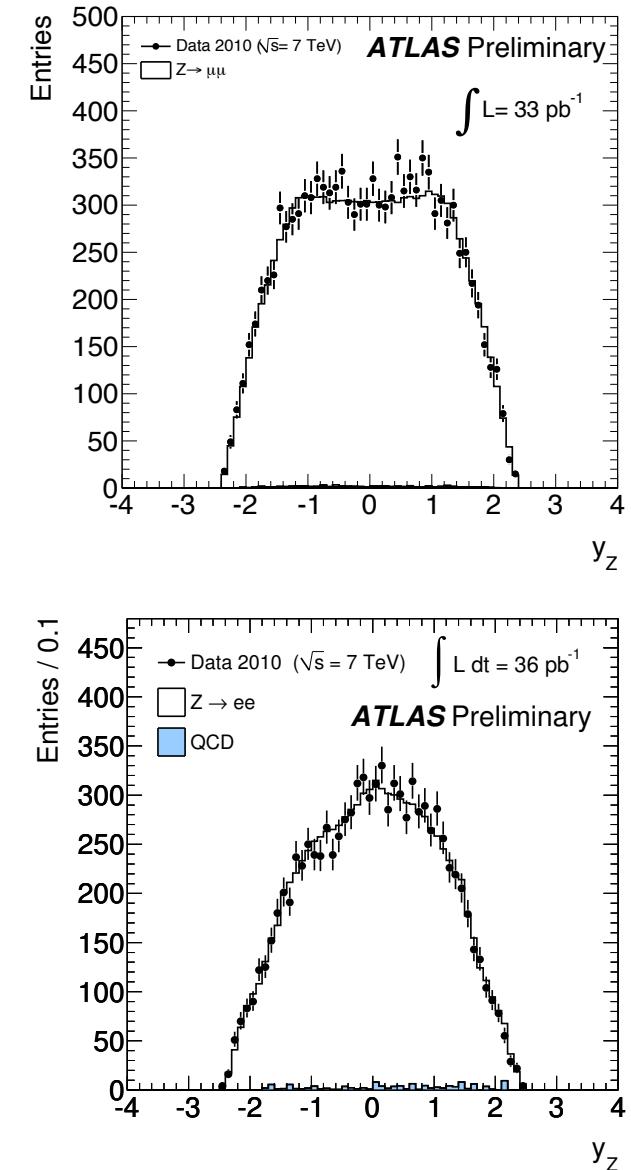
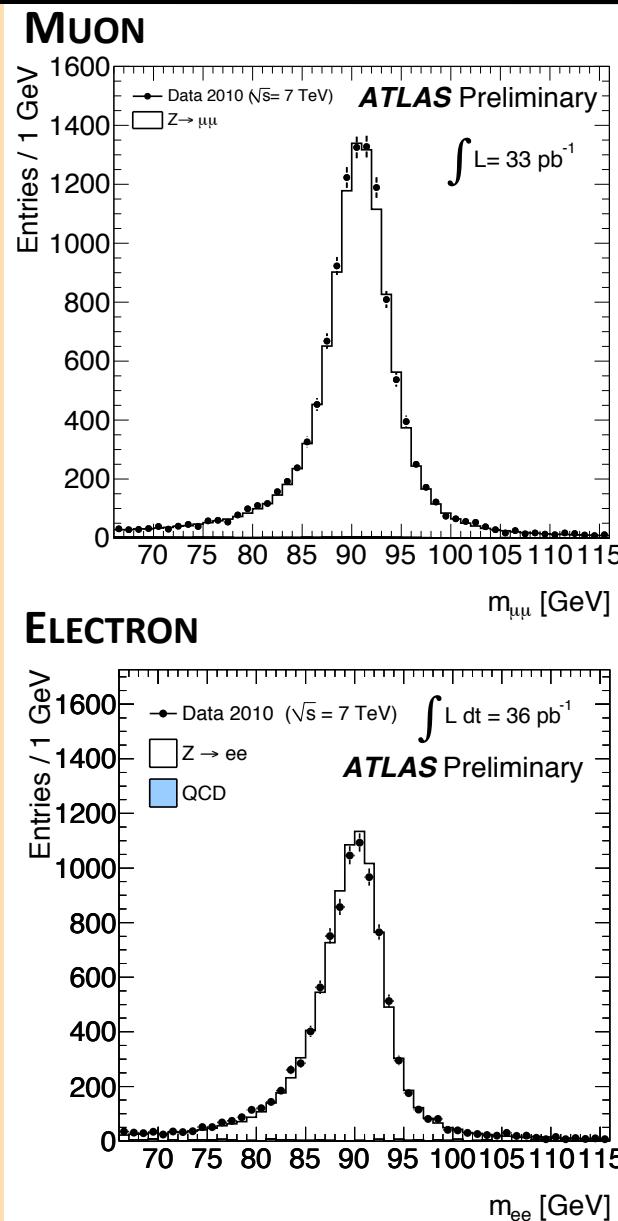
- **$W \rightarrow l\nu$ SELECTION**
 - 1 high p_T lepton
 - $E_T^{\text{miss}} > 25 \text{ GeV}$
 - $m_T > 40 \text{ GeV}$
- **CANDIDATES**
 - MUON **139266**
 - ELECTRON **121310**
- **BACKGROUNDS**
 - MUON
 - $Z \rightarrow \mu\mu$ **3.5%**
 - $W \rightarrow \tau\nu$ **2.8%**
 - QCD **1.7%**
 - ELECTRON
 - $W \rightarrow \tau\nu$ **2.8%**
 - QCD **2.6% (W^+)** and **4.3% (W^-)**



Z BOSON CANDIDATES

ATLAS-CONF-2011-041

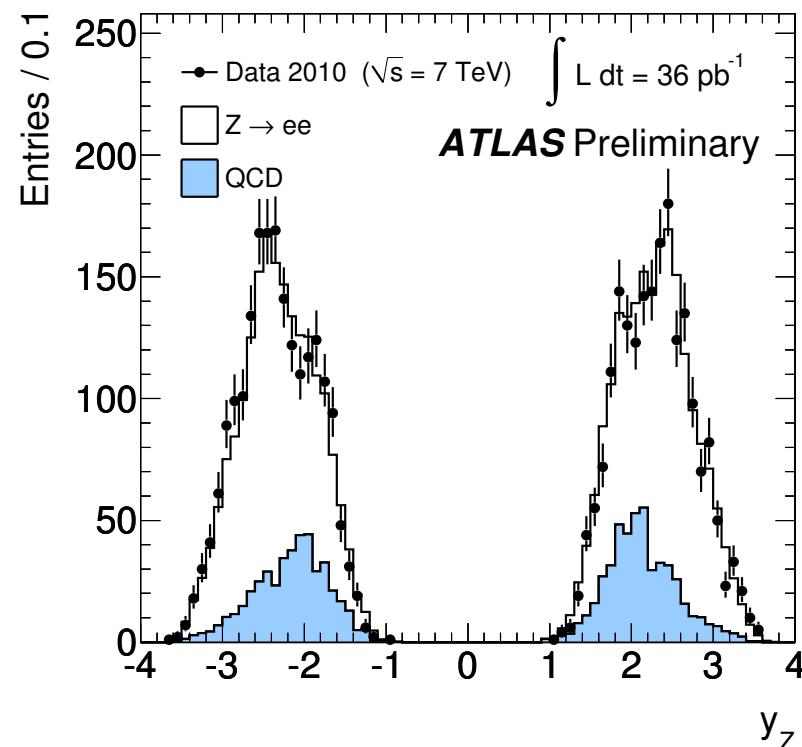
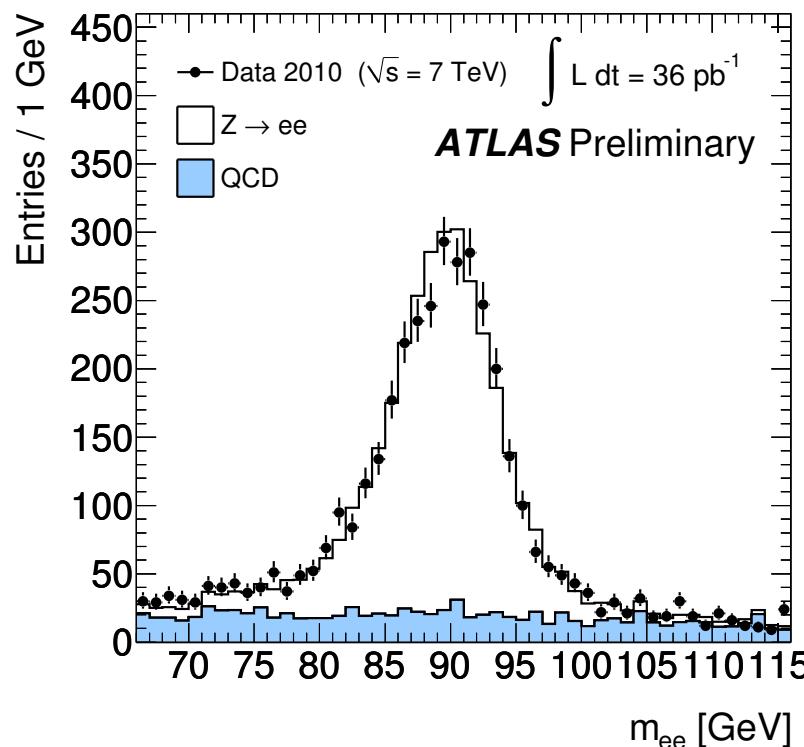
- **Z \rightarrow ll SELECTION**
 - 2 high p_T leptons
 - Opposite charge
 - Invariant mass
 $66 < m_{ll} < 116$ GeV
- **CANDIDATES**
 - MUON **11669**
 - ELECTRON **9721**
- **BACKGROUNDS**
 - MUON
Mostly EW **0.6%**
 - ELECTRON
Mostly QCD **1.8%**



FORWARD $Z \rightarrow ee$

ATLAS-CONF-2011-041

- Measurement of $Z \rightarrow ee$ at larger Z rapidity range extends parton x range probed
 - Use 1 electron in forward $|\eta|$ range 2.47-4.9
 - Selected Candidates **4000**
 - Background **27.5%**
 - Larger QCD background, especially from events with W and forward jet



FIDUCIAL CROSS SECTIONS

ATLAS-CONF-2011-041

- Fiducial cross sections – analysis kinematic requirements
- **Most precise experimental measurements** for comparison to theory

$$\sigma_{W^{(\pm)}}^{fid} \times BR(W \rightarrow l\nu) \quad \sigma_{Z/\gamma^*}^{fid} \times BR(Z/\gamma^* \rightarrow ll), \quad 66 < m_{ll} < 116 \text{ GeV}$$

[nb]	MUON	ELECTRON
W ⁺	3.008 ± 0.011 (sta) ± 0.080 (sys) ± 0.109 (lum)	2.950 ± 0.011 (sta) ± 0.090 (sys) ± 0.100 (lum)
W ⁻	1.950 ± 0.009 (sta) ± 0.053 (sys) ± 0.072 (lum)	1.927 ± 0.009 (sta) ± 0.059 (sys) ± 0.063 (lum)
W	4.959 ± 0.015 (sta) ± 0.120 (sys) ± 0.181 (lum)	4.877 ± 0.015 (sta) ± 0.138 (sys) ± 0.166 (lum)
Z/γ*	0.456 ± 0.004 (sta) ± 0.005 (sys) ± 0.015 (lum)	0.433 ± 0.004 (sta) ± 0.016 (sys) ± 0.015 (lum)
Forward Z/γ*	-	0.179 ± 0.004 (sta) ± 0.017 (sys) ± 0.006 (lum)

- Fiducial region definitions

$$W \rightarrow \mu\nu : p_T^\mu > 20 \text{ GeV}, |\eta_\mu| < 2.4, p_T^\nu > 25 \text{ GeV}, m_T > 40 \text{ GeV}$$

$$W \rightarrow e\nu : p_T^e > 20 \text{ GeV}, |\eta_e| < 2.47, |\eta_e| \notin [1.37, 1.52], p_T^\nu > 25 \text{ GeV}, m_T > 40 \text{ GeV}$$

$$Z \rightarrow \mu\mu : p_T^\mu > 20 \text{ GeV}, \text{both } |\eta_\mu| < 2.4, 66 < m_{\mu\mu} < 116 \text{ GeV}$$

$$Z \rightarrow ee : p_T^e > 20 \text{ GeV}, \text{both } |\eta_e| < 2.47, |\eta_e| \notin [1.37, 1.52], 66 < m_{ee} < 116 \text{ GeV}$$

$$\text{Forward } Z \rightarrow ee : p_T^e > 20 \text{ GeV}, \text{one } |\eta_e| < 2.47, |\eta_e| \notin [1.37, 1.52], \text{other } 2.5 < |\eta_e| < 4.9, 66 < m_{ee} < 116 \text{ GeV}$$

SYSTEMATIC UNCERTAINTIES

ATLAS-CONF-2011-041

$\delta\sigma/\sigma [\%]$	MUON		ELECTRON		
	W	Z	W	Central Z	Forward Z
Trigger	0.7	0.1	0.5	<0.1	0.5
Lepton Reconstruction	0.5	0.8	1.5	3.0	1.5
Lepton Isolation / Identification	0.3	0.6	1.1	1.6	8.2
Lepton Energy Scale	0.4	0.2	0.5	0.2	1.4
Lepton Energy Resolution	0.02	0.02	0.02	0.01	<0.1
Defective LAr Channels	-	-	0.4	0.8	0.8
Charge Mis-Identification	-	-	-	0.2	-
E_T^{miss} Scale and Resolution	2.0	-	2.0	-	-
E_T^{miss} Cleaning / Pile-up	0.07	-	0.1	0.1	1.7
QCD Background	0.8	0.1	0.4	0.3	3.2
EW Background	0.4	0.02			
$C_{W/Z}$ Theoretical	0.3	0.3	0.3	0.5	0.9
Total experimental	2.4	1.1	2.8	3.5	8.6
$A_{W/Z}$ Theoretical	3.0	4.0	3.0	4.0	3.9
Luminosity	3.4				

TOTAL CROSS SECTIONS

ATLAS-CONF-2011-041

- Extrapolation to full kinematic region for total cross section

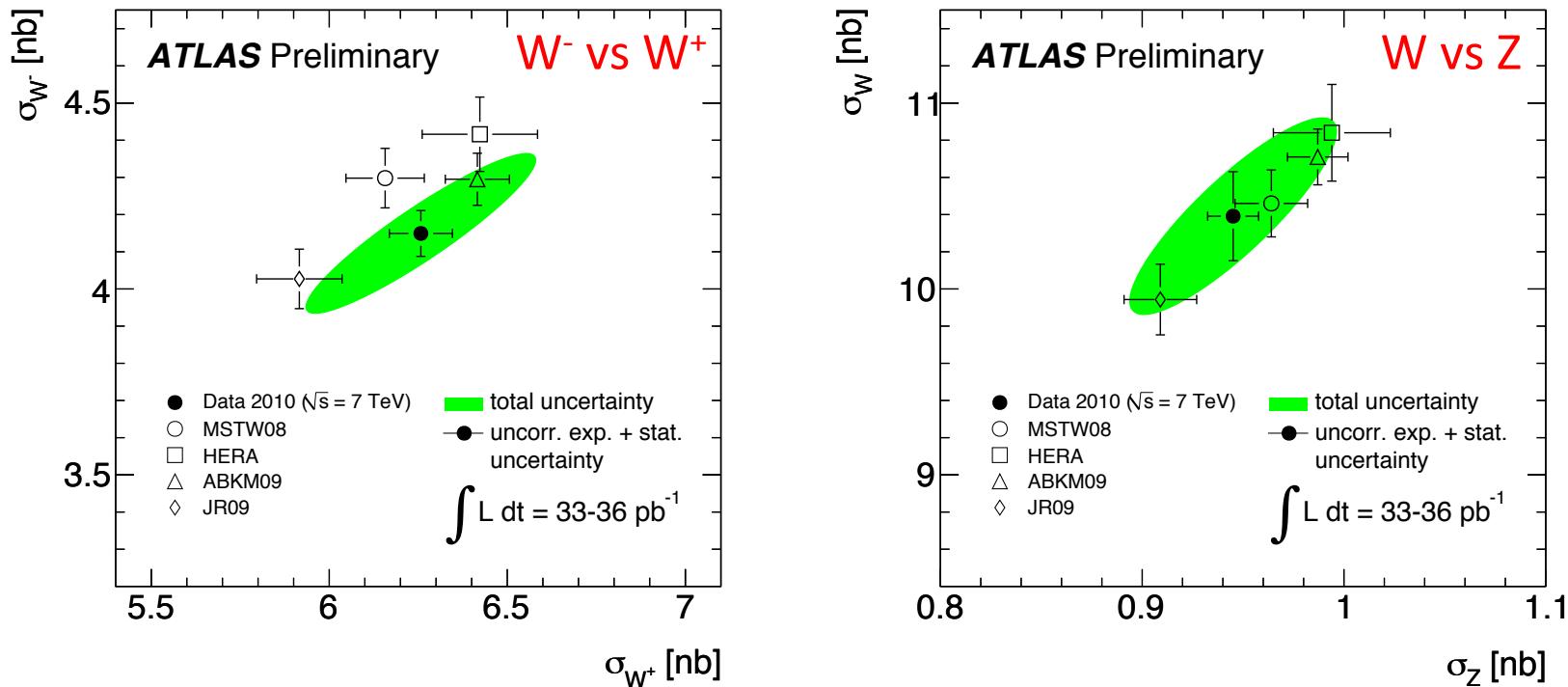
$$\sigma_{W^{(\pm)}}^{tot} \times BR(W \rightarrow l\nu) \quad \sigma_{Z/\gamma^*}^{tot} \times BR(Z/\gamma^* \rightarrow ll), \quad 66 < m_{ll} < 116 \text{ GeV}$$

[nb]	MUON	ELECTRON
W^+	6.215 ± 0.023 (sta) ± 0.165 (sys) ± 0.225 (lum) ± 0.187 (acc)	6.333 ± 0.025 (sta) ± 0.193 (sys) ± 0.215 (lum) ± 0.190 (acc)
W^-	4.107 ± 0.020 (sta) ± 0.112 (sys) ± 0.152 (lum) ± 0.123 (acc)	4.217 ± 0.021 (sta) ± 0.129 (sys) ± 0.138 (lum) ± 0.127 (acc)
W	10.322 ± 0.030 (sta) ± 0.249 (sys) ± 0.377 (lum) ± 0.310 (acc)	10.551 ± 0.032 (sta) ± 0.300 (sys) ± 0.359 (lum) ± 0.316 (acc)
Z/γ^*	0.941 ± 0.008 (sta) ± 0.011 (sys) ± 0.032 (lum) ± 0.037 (acc)	0.972 ± 0.010 (sta) ± 0.034 (sys) ± 0.033 (lum) ± 0.038 (acc)
Forward Z/γ^*	-	0.903 ± 0.022 (sta) ± 0.087 (sys) ± 0.031 (lum) ± 0.035 (acc)

- Measurements consistent for muon and electron channels
 - Forward $Z \rightarrow ee$ result consistent with central measurement
- Central value using PYTHIA MRST LO*
- Acceptance uncertainty from PDFs and NLO contributions

COMBINED CROSS SECTION

ATLAS-CONF-2011-041

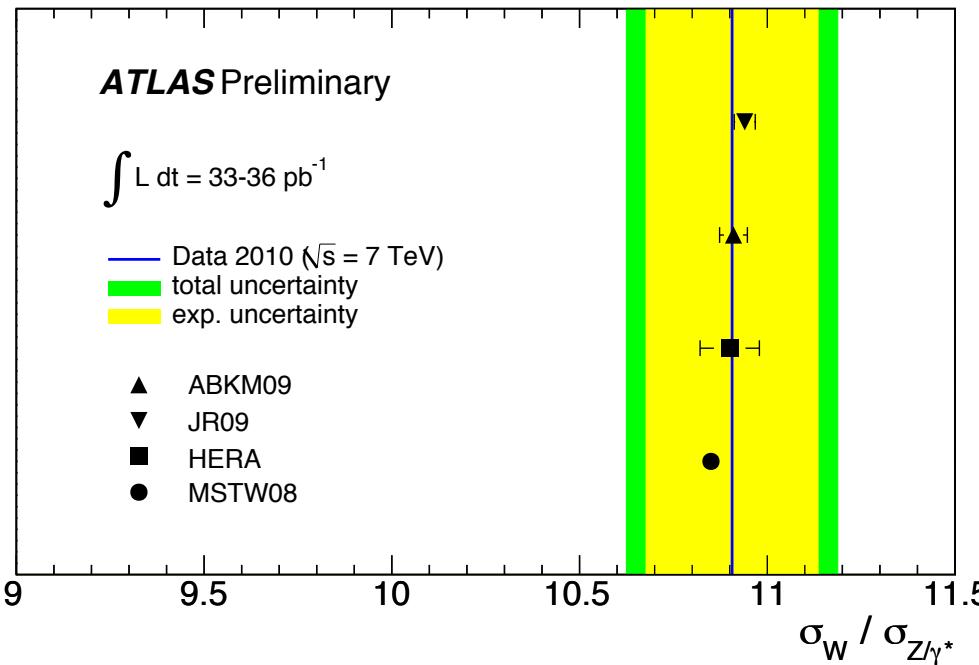


[nb]	Data	MSTW08	HERA	ABKM09	JR09
W^+	$6.257 \pm 0.017 \text{ (sta)} \pm 0.152 \text{ (sys)} \pm 0.213 \text{ (lum)} \pm 0.188 \text{ (acc)}$	6.16 ± 0.11	6.42 ± 0.16	6.42 ± 0.09	5.92 ± 0.12
W^-	$4.149 \pm 0.014 \text{ (sta)} \pm 0.102 \text{ (sys)} \pm 0.141 \text{ (lum)} \pm 0.124 \text{ (acc)}$	4.30 ± 0.08	4.42 ± 0.10	4.29 ± 0.07	4.03 ± 0.08
W	$10.391 \pm 0.022 \text{ (sta)} \pm 0.238 \text{ (sys)} \pm 0.353 \text{ (lum)} \pm 0.312 \text{ (acc)}$	10.46 ± 0.18	10.84 ± 0.26	10.71 ± 0.15	9.94 ± 0.19
Z/γ^*	$0.945 \pm 0.006 \text{ (sta)} \pm 0.011 \text{ (sys)} \pm 0.032 \text{ (lum)} \pm 0.038 \text{ (acc)}$	0.964 ± 0.018	0.994 ± 0.29	0.987 ± 0.015	0.909 ± 0.018

- Measurements consistent (~5% uncertainty) with all NNLO predictions

- Theoretical and experimental uncertainties cancel to large extent in ratio
- Test of Standard Model and sensitive to new Physics

$$R = \frac{\sigma_W \cdot BR(W \rightarrow l\nu)}{\sigma_Z \cdot BR(Z \rightarrow ll)}$$



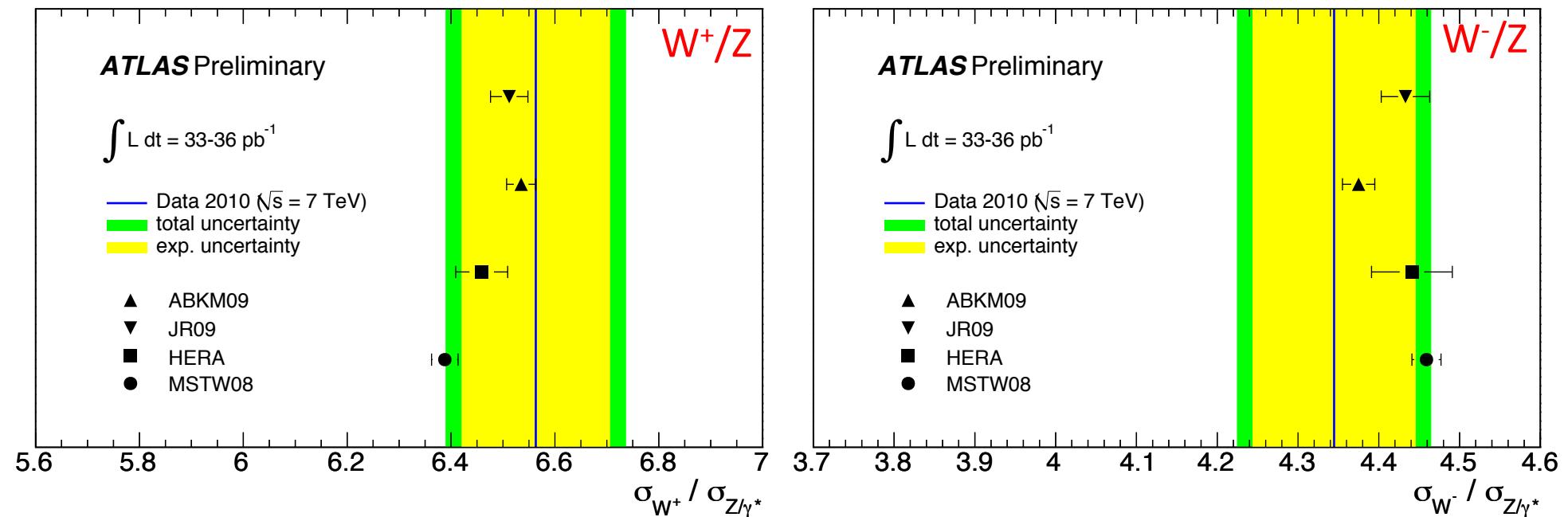
Ratio	Data	ABKM09	JR09	HERA	MSTW08
W/Z	$10.906 \pm 0.079 \text{ (stat)} \pm 0.215 \text{ (syst)} \pm 0.164 \text{ (acc)}$	10.91 ± 0.037	10.94 ± 0.028	10.90 ± 0.079	10.85 ± 0.018

- Good agreement between predictions and measurement

W $^\pm$ /Z RATIOS

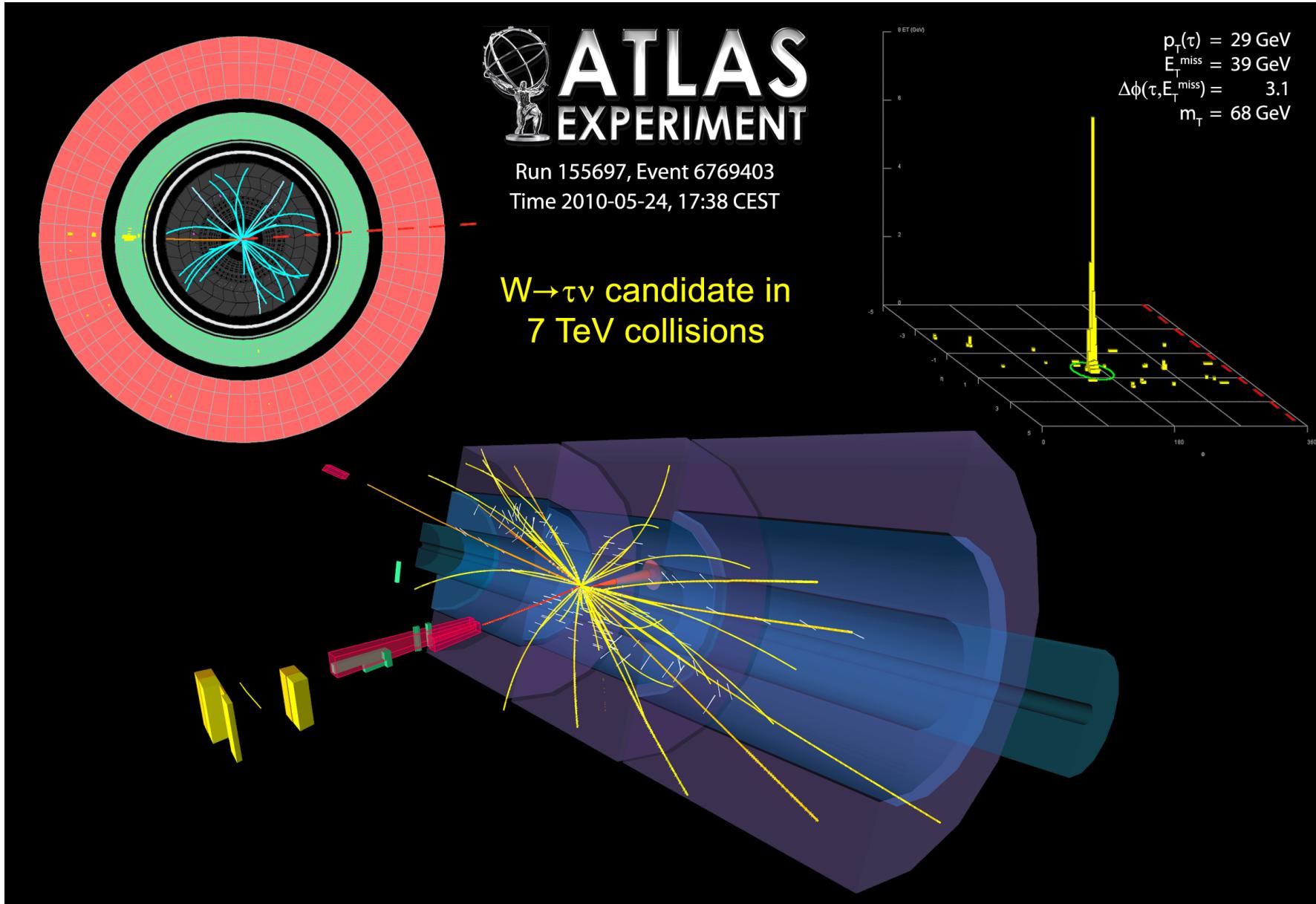
ATLAS-CONF-2011-041

- Separate W $^+$ and W $^-$ over Z ratio distinguishes between u and d quarks



Ratio	Data	ABKM09	JR09	HERA	MSTW08
W $^+$ /Z	$6.563 \pm 0.049 \text{ (stat)} \pm 0.134 \text{ (syst)} \pm 0.098 \text{ (acc)}$	6.535 ± 0.028	6.512 ± 0.036	6.459 ± 0.050	6.388 ± 0.026
W $^-$ /Z	$4.345 \pm 0.034 \text{ (stat)} \pm 0.095 \text{ (syst)} \pm 0.065 \text{ (acc)}$	4.375 ± 0.020	4.433 ± 0.030	4.441 ± 0.050	4.459 ± 0.018

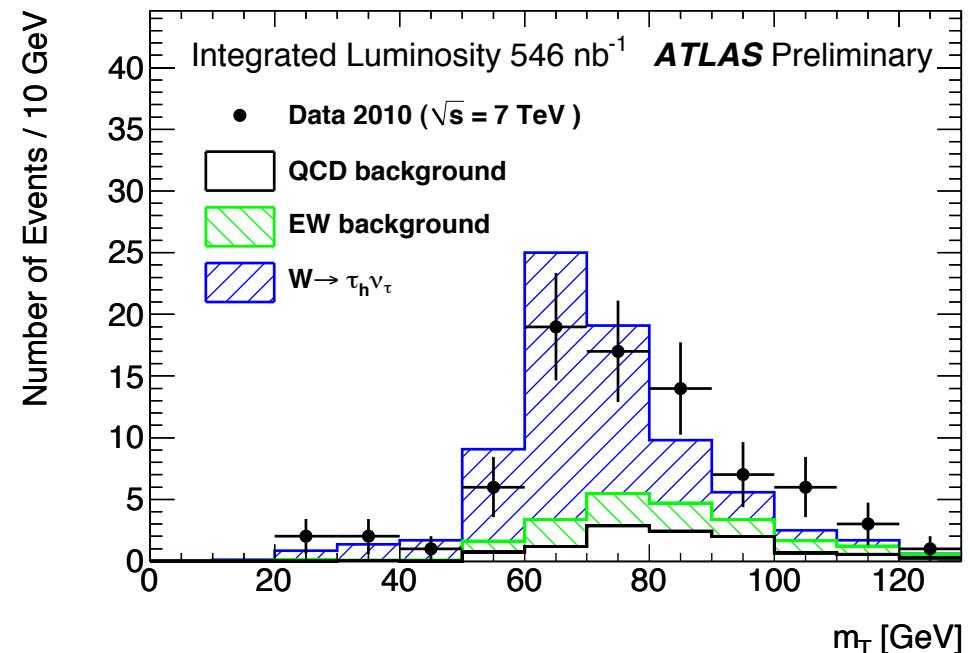
$W \rightarrow \tau \nu$ CANDIDATE EVENT



W $\rightarrow\tau\nu$ OBSERVATION

ATLAS-CONF-2010-097

- W $\rightarrow\tau\nu$ Event Selection **546 nb $^{-1}$**
 - Hadronic τ candidate $20 < p_T < 60$ GeV
 - $E_T^{\text{miss}} > 30$ GeV
 - Jet cleaning to remove fake E_T^{miss}
 - QCD background rejection requirement
- Background estimation
 - QCD background from data
 - W/Z from MC
- Signal yield in agreement with expectation



N_{cand}	$N_{\text{background QCD}}$	$N_{\text{background W/Z}}$	N_{signal}
78	$11.1 \pm 2.3 \text{ (stat)} \pm 3.2 \text{ (syst)}$	$11.8 \pm 0.4 \text{ (stat)} \pm 3.7 \text{ (syst)}$	$55.1 \pm 10.5 \text{ (stat)} \pm 5.2 \text{ (syst)}$

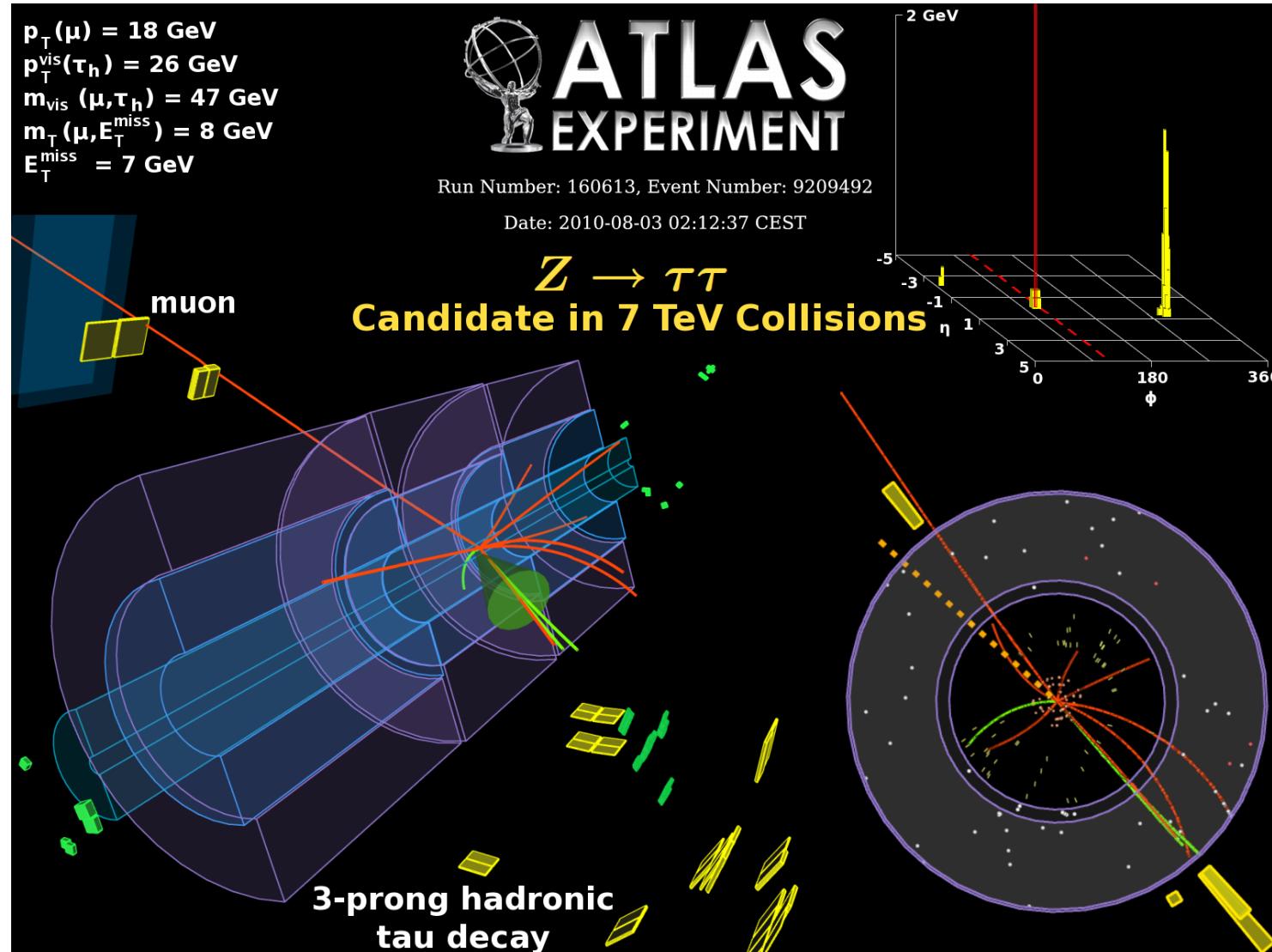
Signal expectation: $55.3 \pm 1.4 \text{ (stat)} \pm 16.1 \text{ (syst)}$

$Z \rightarrow \tau\tau$ OBSERVATION

ATLAS-CONF-2011-010

ATLAS-CONF-2011-045

- Three decay channels $e-\mu$ (35 pb^{-1}), $\mu\text{-hadronic}$ (8.5 pb^{-1}), $e\text{-hadronic}$ (8.3 pb^{-1})



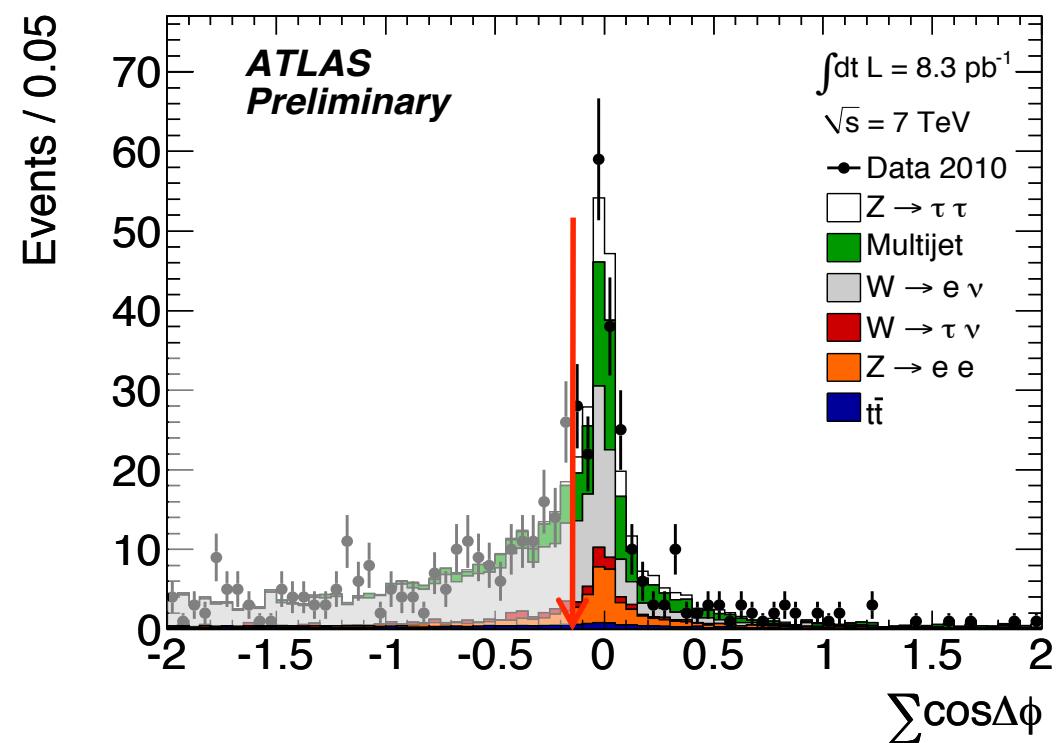
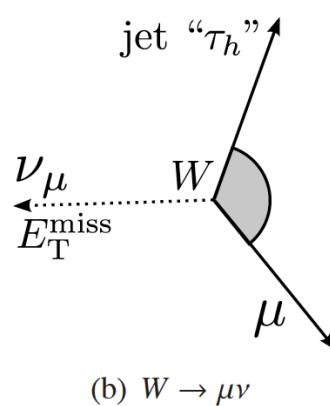
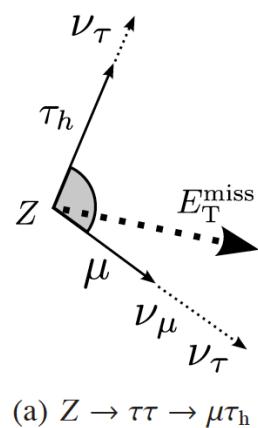
Z $\rightarrow\tau\tau$ EVENT SELECTION

ATLAS-CONF-2011-010

ATLAS-CONF-2011-045

- Leptonic τ : softer lepton $p_T^\mu > 10$ or 15 GeV, electron $E_T > 15$ GeV
 - Isolation using calorimeter and tracking information
- Background suppression requirements for W+Jets ($\sum \cos \Delta\phi$, m_T) and top (scalar ΣE_T)

$$\sum \cos \Delta\phi = \cos(\phi_l - \phi_{E_T^{\text{miss}}}) + \cos(\phi_{\tau_h} - \phi_{E_T^{\text{miss}}})$$

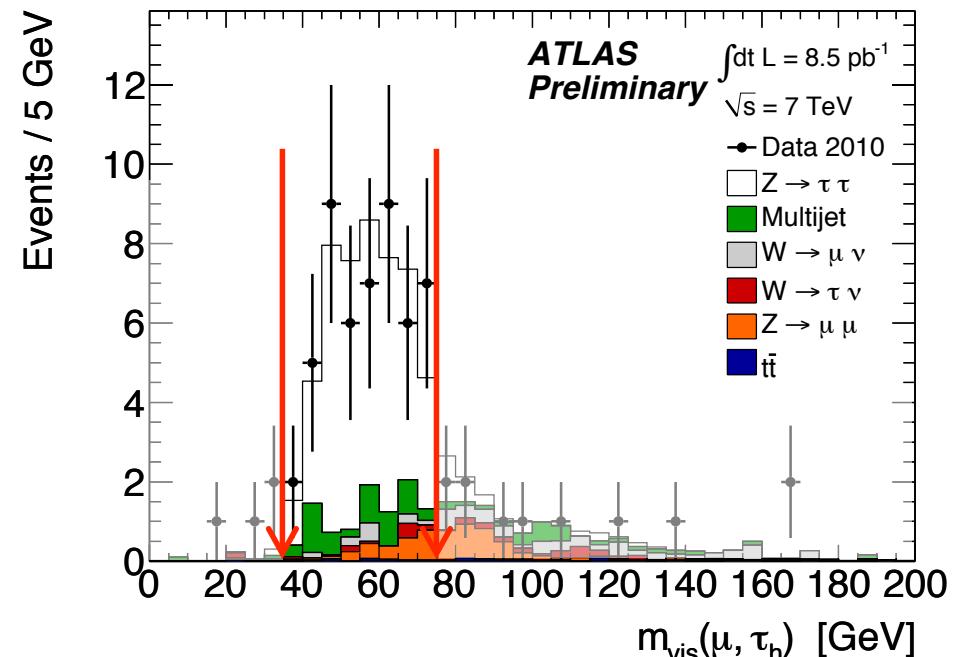
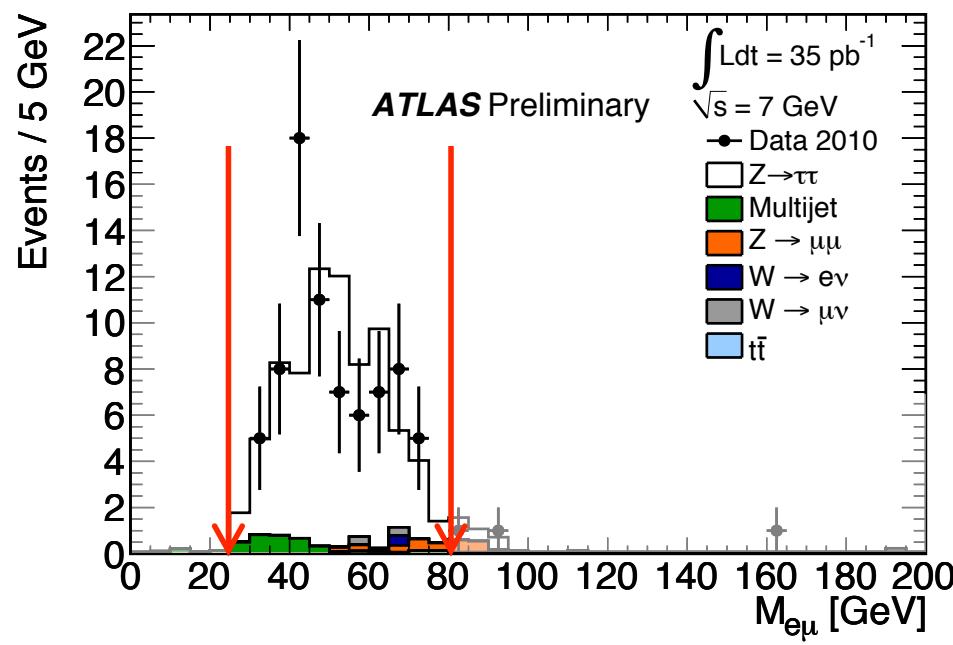


E_T^{miss} between τ_l and τ_h for signal while for background the E_T^{miss} points away from lepton and τ_h candidate (jet fake)

$Z \rightarrow \tau\tau$ OBSERVATION

ATLAS-CONF-2011-010
ATLAS-CONF-2011-045

- Visible mass for candidate selection



- Signal yield in agreement with expectations for all channels

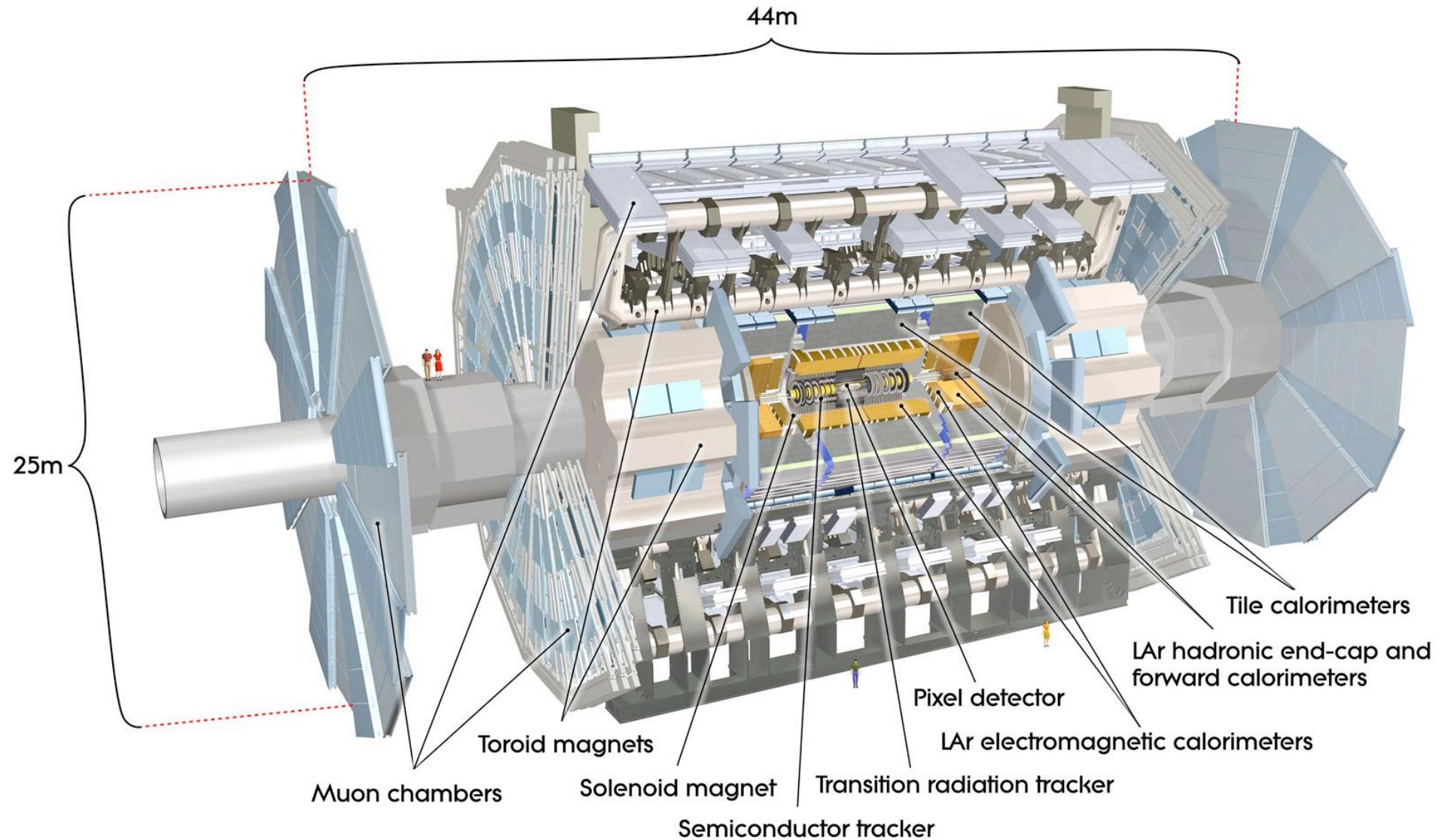
Channel	N_{cand}	$N_{\text{background}}$	N_{signal}	N_{expected}
$\tau_e \tau_\mu$	75	$6.4 \pm 3.9 \text{ (stat+syst)}$	$68.6 \pm 8.7 \text{ (stat)} \pm 3.9 \text{ (syst)}$	$69 \pm 16 \text{ (stat+syst)}$
$\tau_\mu \tau_h$	51	$9.9 \pm 2.1 \text{ (stat+syst)}$	$41.1 \pm 7.1 \text{ (stat)} \pm 2.1 \text{ (syst)}$	$39.9 \pm 1.8 \text{ (stat)} \pm 6.7 \text{ (syst)}$
$\tau_e \tau_h$	29	$11.8 \pm 1.7 \text{ (stat+syst)}$	$17.2 \pm 5.4 \text{ (stat)} \pm 1.7 \text{ (syst)}$	$24.5 \pm 1.4 \text{ (stat)} \pm 7.9 \text{ (syst)}$

SUMMARY

- W and Z boson cross section measurements with full 2010 dataset have reduced statistical and systematic uncertainties
 - Precision measurements for comparison with NNLO predictions
- **Measurements**
 - W and Z inclusive production cross sections (**ATLAS-CONF-2011-041**)
 - W/Z cross section ratio (**ATLAS-CONF-2011-041**)
 - W charge asymmetry (arXiv:1103.2929)
- **Observations**
 - $W \rightarrow \tau\nu$ events (**ATLAS-CONF-2010-097**)
 - $Z \rightarrow \tau\tau$ events (**ATLAS-CONF-2011-010**, **ATLAS-CONF-2011-045**)
- **Outlook**
 - W and Z differential measurements in rapidity and transverse momentum coming soon
 - Updates and more results with 2011 data

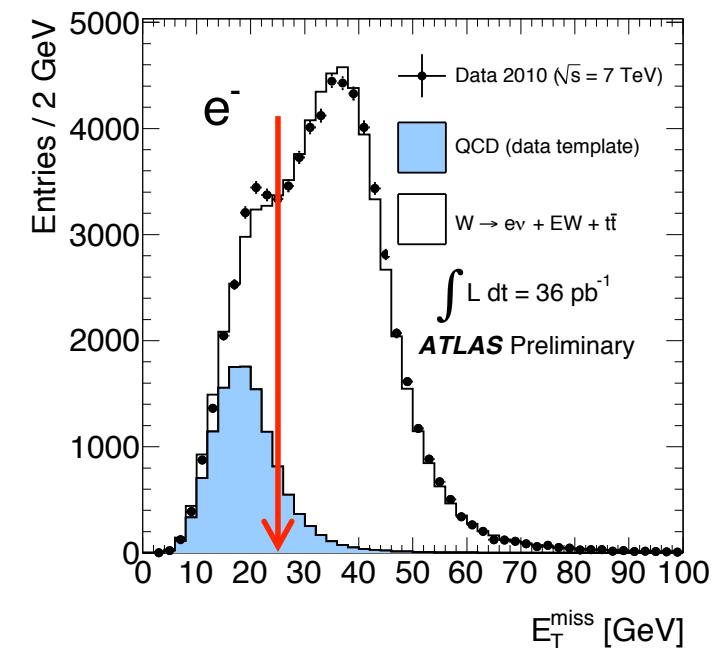
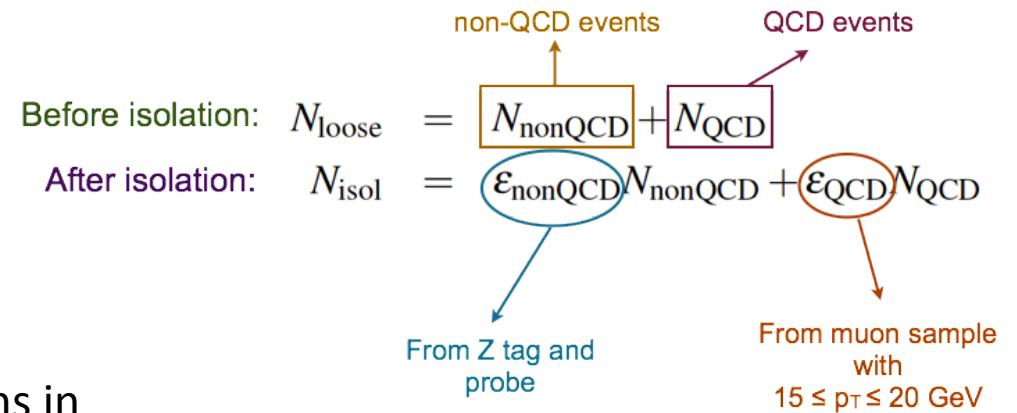
BACKUP

ATLAS DETECTOR



QCD BACKGROUND ESTIMATION

- **MUON**
 - $W \rightarrow \mu\nu$ “Matrix Method” comparison samples before/after isolation
 - Different isolation efficiencies for QCD and non-QCD
 - Predicted background $\epsilon_{\text{QCD}} N_{\text{QCD}}$
 - $Z \rightarrow \mu\mu$ extrapolation from control regions in isolation and $m_{\mu\mu}$
- **ELECTRON**
 - $W \rightarrow e\nu$ Binned maximum likelihood template fit of E_T^{miss}
 - QCD template from data from control sample with reversed ID cuts
 - Signal, EW and top templates from MC
 - Integrate QCD fit result for $E_T^{\text{miss}} > 25 \text{ GeV}$
 - $Z \rightarrow ee$ fits to invariant mass distribution



W AND Z CROSS SECTION COMPONENTS

- Components for W and Z cross section calculation

$$\sigma_{W/Z} = \frac{N - B}{A_{W/Z} \times C_{W/Z} \times \int \mathcal{L} dt}$$

MUON	<i>N</i>	<i>B</i>	<i>C_{W/Z}</i>	<i>A_{W/Z}</i>
W^+	84103	6214 ± 784	0.794 ± 0.020	0.484 ± 0.015
W^-	55163	5569 ± 812	0.780 ± 0.019	0.474 ± 0.014
$W^+ + W^-$	139266	11783 ± 1580	0.790 ± 0.018	0.480 ± 0.014
Z	11669	66 ± 21	0.779 ± 0.009	0.486 ± 0.019

ELECTRON	<i>N</i>	<i>B</i>	<i>C_{W/Z}</i>	<i>A_{W/Z}</i>
W^+	72207	4170 ± 345	0.637 ± 0.019	0.466 ± 0.014
W^-	49103	3925 ± 264	0.647 ± 0.019	0.457 ± 0.014
$W^+ + W^-$	121310	8095 ± 532	0.641 ± 0.018	0.462 ± 0.014
Central Z	9721	217 ± 31	0.606 ± 0.021	0.445 ± 0.018
Forward Z	4000	1099 ± 128	0.448 ± 0.039	0.198 ± 0.008

- Efficiency scale factors included in $C_{W/Z}$ to account for differences data and MC
- $A_{W/Z}$ uncertainty includes PDF uncertainty using CTEQ6.6 error sets (90% C.L.), differences between predictions with different PDF sets and difference with higher order prediction

W AND Z SAMPLE SUMMARY

- **EW and top** backgrounds derived from **MC**
- **QCD** background measured from **data**

	MUON				ELECTRON				
	W ⁺	W ⁻	W	Z	W ⁺	W ⁻	W	Central Z	Forward Z
N _{cand}	84103	55163	139266	11669	72207	49103	121310	9721	4000
N _{bkg}	6214 ±784	5569 ±812	11783 ±1580	66 ±21	4170 ±345	3925 ±264	8095 ±532	217 ±31	1099 ±128

W AND Z FIDUCIAL REGION DEFINITION

- Requirements for fiducial region definition

$W \rightarrow e\nu$: $p_{T,e} > 20 \text{ GeV}$, $|\eta_e| < 2.47$ excluding $1.37 < |\eta_e| < 1.52$,

$p_{T,\nu} > 25 \text{ GeV}$, $m_T > 40 \text{ GeV}$

$W \rightarrow \mu\nu$: $p_{T,\mu} > 20 \text{ GeV}$, $|\eta_\mu| < 2.4$, $p_{T,\nu} > 25 \text{ GeV}$, $m_T > 40 \text{ GeV}$

$Z \rightarrow ee$: $p_{T,e} > 20 \text{ GeV}$, both $|\eta_e| < 2.47$ excluding $1.37 < |\eta_e| < 1.52$,
 $66 < m_{ee} < 116 \text{ GeV}$

Forward $Z \rightarrow ee$: $p_{T,e} > 20 \text{ GeV}$, one $|\eta_e| < 2.47$ excluding $1.37 < |\eta_e| < 1.52$,
other $2.5 < |\eta_e| < 4.9$, $66 < m_{ee} < 116 \text{ GeV}$

$Z \rightarrow \mu\mu$: $p_{T,\mu} > 20 \text{ GeV}$, both $|\eta_\mu| < 2.4$, $66 < m_{\mu\mu} < 116 \text{ GeV}$.

- Definition of efficiency and acceptance factors (cut = fiducial requirements)

$$C_{W/Z} = \frac{N_{\text{MC,rec}}}{N_{\text{MC,gen,cut}}} \quad \text{and} \quad A_{W/Z} = \frac{N_{\text{MC,gen,cut}}}{N_{\text{MC,gen,all}}}$$

FULL SYSTEMATIC UNCERTAINTIES

- MUON

	$\delta\sigma_W/\sigma_W$	$\delta\sigma_{W+}/\sigma_{W+}$	$\delta\sigma_{W-}/\sigma_{W-}$	$\delta\sigma_Z/\sigma_Z$
Trigger	0.7	0.8	0.9	0.1
Muon Reconstruction	0.5	0.6	0.6	0.8
Muon Isolation	0.3	0.3	0.3	0.6
Muon p_T Resolution	0.02	0.03	0.02	0.01
Muon p_T Scale	0.4	1.1	0.8	0.2
QCD Background	0.8	0.7	1.1	0.1
Electroweak Background	0.4	0.4	0.5	0.02
E_T^{miss} Cleaning	0.07	0.07	0.07	-
E_T^{miss} Resolution and Scale	2.0	2.0	2.0	-
$C_{W/Z}$ Theoretical uncertainty	0.3	0.3	0.3	0.3
Total experimental uncertainty	2.4	2.7	2.7	1.1
$A_{W/Z}$ Theoretical uncertainty	3.0	3.0	3.0	4.0
Total excluding Luminosity	3.9	4.0	4.0	4.1
Luminosity		3.4		

- ELECTRON

	$\delta\sigma_W/\sigma_W$	$\delta\sigma_{W+}/\sigma_{W+}$	$\delta\sigma_{W-}/\sigma_{W-}$	Central $\delta\sigma_Z/\sigma_Z$	Forward $\delta\sigma_Z/\sigma_Z$
Trigger	0.5	0.5	0.5	<0.1	0.5
Electron Reconstruction	1.5	1.5	1.5	3.0	1.5
Electron Identification	1.1	1.2	1.1	1.6	8.2
Electron Energy scale	0.5	0.5	0.4	0.2	1.4
Electron Energy resolution	0.02	0.02	0.02	0.01	<0.1
defective LAr channels	0.4	0.4	0.4	0.8	0.8
Charge misidentification	—	1.1	1.1	0.2	—
E_T^{miss} scale and resolution	2.0	2.0	2.0	—	—
pile-up	0.1	0.1	0.1	0.1	1.7
Background	0.4	0.5	0.5	0.3	3.2
$C_{W/Z}$ Theoretical uncertainty	0.3	0.3	0.3	0.5	0.9
Total experimental uncertainty	2.8	3.0	3.0	3.5	8.6
$A_{W/Z}$ Theoretical uncertainty	3.0	3.0	3.0	4.0	3.9
Total excluding Luminosity	4.1	4.2	4.2	5.3	9.4
Luminosity		3.4			

- Largest experimental uncertainties
 - Lepton reconstruction identification efficiencies
 - E_T^{miss} scale and resolution
- Experimental uncertainties comparable to theoretical uncertainties
- Luminosity uncertainty 3.4%

$W \rightarrow \tau\nu$ EVENT SELECTION

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- Performance of τ lepton reconstruction
- Hadronic τ candidate
 - $20 < p_T < 60$ GeV
 - $|\eta| < 2.5$ excluding $1.3 < |\eta| < 1.7$
- No jet with $p_T > 20$ GeV in $1.3 < |\eta| < 1.7$
- $\Delta\phi(\text{jet}, E_T^{\text{miss}}) > 0.5$
- $E_T^{\text{miss}} > 30$ GeV
- $E_T^{\text{miss}} / 0.5 \sqrt{\sum E_T} > 6$
- Background estimation
 - QCD background from data
 - W/Z from MC

